

Geomagnetic Variability and Predictability

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The Earth's magnetic field varies on time scales from seconds to millions of years. These variations can be measured directly by ground observatories and satellites, and indirectly through laboratories. They are from different electromagnetic processes in magnetosphere and ionosphere (external), ocean and crust (surface), and deep in the Earth's fluid outer core (internal). Of the measured magnetic signals, 95% is from the core, and is called the core field, or internal field. Variation of the core field, often called the geomagnetic secular variation (SV), is the manifestation of the magneto-hydrodynamic processes in the core. Therefore, SV provides rich information on the core dynamical state that is then critical for understanding the geophysical mechanisms of the SV, the core-mantle interactions, and contribution of mass transport inside the core on Earth's gravity variation.

Traditionally, the core state is probed via two independent methodologies: core flow inversion from the observed SV, and pure numerical dynamo simulation. The former is driven by observations, but does not include necessary interactions among physical variables; the latter is dynamically consistent, but is not constrained by any observation. Therefore, both are very limited in providing appropriate estimates of the core state. To avoid these limitations, a new approach, geomagnetic data assimilation, appears recently. In this approach, simulation results (model forecasts) are constantly corrected with observations, the corrected solutions (analysis), are then used as the initial conditions to make more accurate forecasts of future. Recent studies have demonstrated successfully that assimilation solutions are different from those of free running models. These new solutions are better estimates of the core state, and have been used to provide accurate prediction of SV for the period from 2010 to 2015. This prediction is part of the IGRF field model for international community applications.